INDIUM

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All refined indium production in the United States during 2004 came from the refining of lower grade imported indium metal and from refining of scrap. Two refineries, one in New York and the other in Rhode Island, produced the majority of indium metal and indium compounds in 2004. A number of small companies produced specialty indium alloys and other indium products.

Domestic consumption of indium in 2004 was estimated by the U.S. Geological Survey to have increased to about 100 metric tons (t). Most of the estimated increase was in the use of coatings. Domestic consumption distribution for 2004 was 70% for coatings, 15% for solder and alloys, 10% for electrical components and semiconductors, and 5% for other uses. The value of indium consumed in the United States in 2004 was about $57 million at an average New York, NY, dealer price of $574 per kilogram, as calculated from prices published in Platts Metals Week.

World primary refined production increased by 14%, compared with production in 2003. The three major producing countries of refined indium recovered from domestic or imported concentrates or residues, in decreasing order of production, were China, Japan, and Canada. A small quantity of primary refined production came from Belgium and Russia (table 2). Recycling of indium scrap continued to modestly increase.

World consumption increased in 2004 owing to a worldwide continuation of strong markets for laptop computers, flat panel displays (FPDs), and other liquid crystal displays (LCDs) that use indium-tin oxide (ITO) coatings, as well as growth in the use of other technologies that used ITO coatings and indium metal. An increase in the size of the monitors and televisions produced also contributed to the higher consumption levels.

World indium reserves, which are based on estimated indium content of zinc reserves, are estimated to be about 2,500 t. If an assumption is made that more than one-half of the world's consumption will be met from the recycling of existing materials, these reserves would last about 10 years. The world reserve estimation excludes about a 30-year supply of indium contained in the estimated zinc reserve base that could become available through new technologies or additional exploration and reserve delineation. Canada has the world's leading reserves at about 28% of the total, and the United States holds about 12% of the world's reserves.

Production

U.S. production of indium in 2004 consisted of upgrading imported indium metal. Lower grade (99.97%) and standard-grade (99.99%) imported indium was refined to purities of up to 99.9999%. Indium Corporation of America, Utica, NY, and Umicore Indium Products (a division of n.v. Umicore s.a.), Providence, RI, accounted for the major share of U.S. production of indium metal and products.

Indium metal is sold in various forms (ingot, foil, powder, ribbon, wire, and others) as well as different grades. Many small companies produced high-purity indium alloys, compounds, solders, ITO coatings, and other indium products.

Small amounts of new indium scrap were recycled in 2004, as has been the case in recent years. Unlike some Asian countries, where substantial amounts of indium are recycled, there was no well developed infrastructure for collection and consumption of indium-containing scrap and waste in the United States.

Consumption

The use of indium in coatings, which was mainly in the form of indium oxide and ITO, constituted more than two-thirds of total domestic indium use in 2004. The major use for these coatings was for thin-film coatings on glass and on LCDs. The use of ITO in organic light-emitting diode and plasma displays is a relatively small segment of coating use, but it is expected to have strong growth during the next several years.

Two types of coatings contain indium—electronically conductive and infrared-reflective. LCDs for portable computer screens, television screens, video monitors, and watches, which were the major commercial applications, use electrically conductive coatings. They are also used to defog aircraft and locomotive windshields and to keep glass doors on commercial refrigerators and freezers frost-free. Indium coatings on window glass take advantage of indium's infrared reflective properties and limit the transfer of radiant heat through the glass. This property of indium can be used to heat and cool buildings more efficiently.

The technologies of glass coatings and semiconductors have been the leading areas of research and development for indium during the past several years. Although coatings remained the most widespread use for indium, the production of electrical components and semiconductors is expected to be a major growth application for indium during the next several years.

In recent years, light-emitting diodes (LEDs) have shown growth potential. Anything that uses lights or some type of electronic display can use LEDs. LEDs now come in many colors and can be bright enough to be used for lighting. For example, the U.S. Department of the Interior's National Park Service recently teamed up with Osram Sylvania (a division of Osram GmbH) to relamp the Thomas Jefferson Memorial in Washington, DC, by using 17,000 LEDs. The electrical requirements were reduced by 80%, with 20% fewer fixtures and 30% more lighted area. In addition to cost savings, the amount of mercury used in the original 35-year-old lighting system was reduced. These LED lights are mechanical-shock-, temperature-, and weather-resistant and have a long life (U.S. Department of the Interior, National Park Service, 2004§[1]). Other examples of LED applications were airport lights, backlighting, infrared transmitters, outdoor signs, Jumbotrons, personal electronic displays, variable message signs on highways, vehicle lights, as well as emergency lights, flashlights, and other low-wattage applications (Whitaker, 2003).

About one-sixth of the indium used was combined with other metals to form low-melting-point alloys and solders. The alloys find various applications such as in electrical fuses and fusible links and as gripping tools for the grinding of delicate materials. The advantages of indium-containing solders are that they have lower melting points, are more flexible over a wider temperature range, and inhibit the leaching of gold components in electronic apparatus.

Alkaline batteries used indium to prevent buildup of hydrogen gas within sealed battery casings. Indium was also used in semiconductors, including semiconductors in fiber optics. This category of usage declined during the last several years because of a decline in investments in telecommunication systems. Other uses of indium included dental alloys, electrode-less lamps, mercury alloy replacements, nuclear control rods, phosphors, and white gold alloys.

Prices

The price of indium rose dramatically during 2004, approximately tripling. The average New York dealer price, as reported by Platts Metals Week, for 99.97%- to 99.99%-pure indium began the year at $305 to $335 per kilogram. The price rose rather steadily through the year, reaching $590 to $640 per kilogram by the end of August, and ended the year at $770 to $830 per kilogram.

According to Platts Metals Week, the Indium Corporation of America producer price of indium started the year at $265 per kilogram. It continued to rise in rather steady increments through the year, ending 2004 at $800 per kilogram.

The remarkable price increase was attributed by industry sources to the following factors: 1) a substantial growth in demand for ITO, especially in Japan and the Republic of Korea; 2) demand increases for low-melting-point indium in China; and 3) an undersupply owing to continued shortages of raw material in China and the closure of production facilities in France.

Trade

U.S. imports of indium in 2004 increased by about 16% to 143 t compared to those of 2003. China was the leading source of U.S. indium imports in 2004 and accounted for 46% of the total imported, followed in declining order of importance as a source, by Canada, Japan, and Belgium.

World Review

Belgium.—Umicore (Brussels) remained one of the world's foremost indium refiners. The firm also produced a wide variety of downstream indium products such as ITO.

Canada.—Falconbridge Ltd. (Toronto, Ontario) continued as one of Canada's two indium refiners, through its Kidd Creek, Ontario, refinery. The other Canadian producer was Teck Cominco Ltd., at its Trail, British Columbia, smelter and refinery. Both Falconbridge and Teck processed indium materials that originated primarily in their own mines.

China.—The heart of China's indium producing area in Nandan County remained closed since 2001, with no reopening planned for the near future. China continued to be the world's leading refined indium producer, producing almost one-half of the world's total output.

Zhuzhou Smelter Non-Ferrous Co. Ltd remained China's leading indium smelter.

Chenzhou Hualin announced plans to increase its refined indium production to 10 t in 2004. The firm had upgraded its production capability in 2003 to be able to make refined indium instead of merely crude indium. The company had produced 3 t of indium in 2003 (Metal-Pages, 2005b§).

Yongxing Nonferrous announced plans to build a crude indium production plant with a capacity of 5 metric tons per year (t/yr) (Metal-Pages, 2004c§).

China Tin Group reportedly was producing indium at a rate of 24 t/yr, similar to production of prior years. The firm may be one of the few indium producers in China to have sufficient raw material to maintain its production, while most experienced supply shortages. The company was the only state-owned indium smelter in Guangxi Province with its own mines to supply ore with rich indium content (Metal-Pages, 2004a§).

Japan.—Japan continued to be a focal point for indium activity, both as a producer and more importantly, as a consumer. Dowa Mining Co. Ltd. reportedly continued to increase its output of refined indium metal. On the consumption side, Japanese firms registered gains in production of ITO as well as consumption of ITO, primarily for thin-film coatings on glass and LCDs. Asahi Glass Co., Nippon Electric Glass Co., and NH Techno Glass Corp. were active in the production of LCD glass substrates for the LCD market.

Korea, Republic of.—Korea Zinc Co. announced plans to construct a $4 million indium refinery at its plant in the port city of Onsan, southeast of Seoul. Company officials expected to be producing indium at a rate of 34 t/yr by spring 2005. Korea Zinc was one of the main producers of LCDs, especially for FPD units for televisions, computers, and mobile phones, with Samsung Electronics Co. Ltd. ranked as one of the leading world producers (Metal-Pages, 2004e§).

[1]References that include a section mark (§) are found in the Internet References Cited section.

Current Research and Technology

In Japan, researchers at the Tokyo Institute of Technology announced the development of a transparent transistor deposited on plastic. The transparent semiconductor is made from indium-gallium-zinc oxide. Prototype transistors made from this material have proven to be 10 times as conductive as transistors used in modern LCDs. Depositing standard silicon transistors on plastic would be impossible because the process requires substantial heat that would melt the plastic, whereas the indium-gallium-zinc oxide applies to plastic at room temperature. As well as providing for many specialty applications, transparent circuitry could make electronic displays brighter by increasing the amount of light reaching the viewer's eyes (Metal-Pages, 2004d§).

While the potential demand for indium in one application as ITO for FPDs was strong, another indium end use, the use of indium phosphide (InP) bulk substrates in fiber optics, was in the early stages of development and was considered to have only modest growth potential for the next few years (Metal-Pages, 2004b§).

Eikos Corp. (United States) began developing carbon nanotubes that could replace indium-tin oxide in thin films for displays. In addition to lower costs, the carbon nanotube thin films, known as Invision, form a rigid substrate and thus could be used for fabrication of flexible displays that are lighter and thinner (Metal-Pages, 2005a§).

Outlook

Indium consumption was expected to increase during the next few years. Leading the way was indium applications for ITO intended for LCDs. Several companies in Japan, the Republic of Korea, and Taiwan announced that they are increasing the size (area) of the glass used to make these displays, and that will also increase the amount of ITO needed per unit. Global LCD sales were expected to increase by 80% by 2005, as compared with those of 2002, to 120 million units.

On the supply side, a critical element will be the ability of individual countries to recycle indium-containing electronic components, which tend to have a relatively short life cycle. Since indium is mostly a byproduct of zinc mining and smelting, it will be hard to increase primary production unless there is an increase in zinc production. During the past decades, dwindling zinc prices forced some high-cost and low-grade underground zinc mines and a few older and less efficient zinc refineries to close. Now, the price of zinc has risen, and with it zinc production could be expected to rise. With that scenario, primary indium production should also increase, but production was expected to remain below worldwide demand.

Reference Cited

Whitaker, Tim, 2003, Backlights, airports and vehicles boost LED market: Compound Semiconductor, v. 9, no. 11, December, p. 20-22.

Internet References Cited

Metal-Pages, 2004a (October 20), China Tin maintains In output, accessed October 23, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004b (December 21), Demand for In in fibre-optics subdued, accessed December 23, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004c (October 25), Indium plant nears completion, accessed October 28, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004d (December 13), InGaZn oxide roll-up display screens, accessed December 13, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2004e (November 8), Korea Zinc to start indium production in March, accessed November 8, 2004, via URL http://www.metal-pages.com.
Metal-Pages, 2005a (April 4), Carbon nanotubes versus ITO, accessed April 4, 2005, via URL http://www.metal-pages.com.
Metal-Pages, 2005b (February 25), Indium output increase on track, accessed February 25, 2005, via URL http://www.metal-pages.com.
U.S. Department of the Interior, National Park Service, 2004, Lighting of Thomas Jefferson Memorial, accessed June 24, 2004, at URL http://www.nps.gov/partnerships/lighting_jefferson_memorial.html.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Indium. Ch. in Mineral Commodity Summaries, annual.
Gallium, Germanium, and Indium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Other

Indium. Ch. in Minerals Facts and Problems, U.S. Bureau of Mines Bulletin, 675, 1985.

TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT AND WASTE AND SCRAP
OF INDIUM, BY COUNTRY[1, 2]

	2003		2004	
Country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	4,770	$742	10,300	$5,860
Canada	20,800	2,410	22,800	12,100
Costa Rica	1	4	2	12
Denmark	--	--	30	4
China	61,400	8,700	66,100	20,200
France	2,670	445	7,150	283
Germany	966	199	339	99
Hong Kong	1,120	205	3,230	1,780
India	--	--	1	3
Israel	6	4	--	--
Italy	--	--	230	126
Japan	19,800	2,370	22,300	12,600
Macao	--	--	100	84
Mexico	--	--	35	3
Netherlands	45	10	546	431
Peru	4,330	655	2,130	1,330
Russia	6,150	776	3,560	2,110
Taiwan	--	--	100	49
United Kingdom	628	106	3,510	1,750
Total	123,000	16,600	143,000	58,800

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes indium powder.

Source: U.S. Census Bureau.

TABLE 2

INDIUM: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2000	2001	2002	2003	2004
Belgium	40	40	40	30	30
Canada	45	45	45	50	50
China	200 r	159 r	110 r	150 r	200
France	65	65	65	10	10
Germany	10	10	10	10	10
Italy	5	5	5	5	5
Japan	55 [3]	55	60	70	70
Kazakhstan	NA	NA	NA	NA	NA
Netherlands	5	5	5	5	5
Peru	5 [3]	4 [3]	6 [3]	6 r	6
Russia	15	15	15	15	15
Ukraine	NA	NA	NA	NA	NA
United Kingdom	5	5	5	5	5
Total	450 r	408 r	366 r	356 r	406

r Revised. NA Not available.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 3, 2005.

[3] Reported figure.